THE USE OF CLIMATE FORECASTS IN AGRICULTURE: EXPERIENCE IN THE AMERICAS

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Introduction

I will present an overview of experience in applying seasonal climate forecasts to agriculture in the Southeast US. The El Niño-Southern Oscillation (ENSO) exerts a substantial influence on the climate and diverse agricultural production systems of the region. Predictability of ENSO and its influence on climate and agriculture represents an opportunity to adjust decisions to either mitigate impacts of adverse conditions or take advantage of favorable conditions.

The IRI seeks to support, collaborate with, and learn from the many other research groups and institutions who share in our quest to enhance society's capacity to understand, anticipate and manage the impacts of climate variations. One research group is a Consortium of Florida universities, led by our session chair, Professor Jim Jones, and other colleagues at the University of Florida, Florida State University and the University of Miami. Since 1996, the interdisciplinary Florida Consortium team has been conducting applied research in the Southeast USA and Latin America designed to reduce economic risk and improve well-being by facilitating the routine and effective use of climate forecasts for agricultural decision making. Although I am no longer directly involved, I had the privilege of being part of the effort's earlier development. My purpose is two-fold: First, to spark your imagination by illustrating in one particular context the potential for agriculture to benefit from seasonal climate forecasts. And second, to illustrate elements of a sensible approach toward achieving those benefits. The approach starts with a foundation of understanding of: (a) ENSO's impacts on climate and agricultural systems, (b) the perceptions and needs of farmers and their advisors, and (c) climate-sensitive decisions that might benefit from forecast information. I will then discuss the delivery of climate information, and the process of developing sustained institutional support for climate forecast applications.

Understanding ENSO's Impacts

Analyses of historic time-series data enabled us to understand and quantify impacts of ENSO on the region's climate and agriculture. In the winter and early spring, El Niño is associated with enhanced precipitation and reduced daytime temperatures in most of the Southeast (Green et al., 1997). Summer impacts of El Niño are more localized, and include drier conditions along the Atlantic Coast and from North Texas to northern Alabama. El Niño conditions also significantly reduce frequency of hurricanes in the region (O'Brien et al., 1996). Climatic impacts of La Niña are generally, but not always, opposite those of El Niño. They include reduced winter precipitation, and enhanced springtime precipitation tends to increase in the Gulf Coast region in the spring. We have some evidence that the summer rainy season occurs earlier in southern Georgia and Alabama in La Niña years.

The U.S. summer cropping season is out of phase with the period when ENSO has its greatest influence.

Yet, we found that, in addition to winter wheat, ENSO significantly influences yields of corn, cotton, tomato, sugarcane and hay in an eight-state region in the Southeast (Hansen et al., 2001). Yield response of several field crops to the two recent very strong El Niño events (1982-83 and 1997-98) was opposite in direction to their response to weak-to-moderate El Niño events (Fig. 1). After adjusting for inflation and trends in area and technology, ENSO phases account for average shifts of $212 million, or 26% of the aggregate value of corn, and $133 million, or 18% of the value of soybeans in Florida, Alabama, Georgia and South Carolina (Fig. 2) (Hansen et al., 1998a). In Florida, ENSO also significantly influences yields of high-value crops, such as some citrus species and winter-grown fresh vegetables (tomato, bell pepper, snap beans and sweet corn, Fig. 3) (Hansen et al., 1998b, 1999). Prices of winter-grown bell pepper and snap bean in Florida show a significant response opposite in direction to the yield responses to ENSO (Fig. 4). The aggregate value of Florida tomatoes has averaged $26 million, or 22%, higher in La Niña than in neutral or El Niño winters (Fig. 5) (Hansen et al., 1999).

Understanding Decision Makers

The size and diversity of Florida's agricultural sector make understanding its climate information needs in a comprehensive manner a daunting task. Our efforts to understand agricultural decision makers have included farmer weather and climate workshops; farmer surveys in northern Florida and southern Georgia and Alabama, open-ended surveys of Florida Agricultural Extension Service personnel; participation in District Extension meetings and Extension training workshops; and various interactions with agribusiness. Surveys of extension personnel, who daily interact with and advise farmers, proved to be a particularly effective means of learning about farmer perspectives, and opportunities for using climate information.

Our interactions with farmers reveal consistent concern about weather events, particularly hurricanes, freezes, floods and abnormally high temperatures. Attitudes toward seasonal prediction, on the other hand, range from strong skepticism to moderate optimism, with skepticism more common. Reasons for skepticism include lack of understanding of how ENSO influences the region’s climate, and lack of information about forecast uncertainty at particular locations and times of year. Awareness of spatial variability of local weather translates into desire for climate forecasts for farmers’ specific locations. However, farmers often also ask about forecasts for their competitors' regions. While rainfed field crop producers are concerned about climate fluctuations, market variations tend to dominate decisions for high-value crops. Perceived flexibility to adjust management in response to climate expectations varies considerably among farm types. Regardless of their level of confidence or perceived flexibility to respond to seasonal forecasts, farmers are consistently interested in learning more about ENSO impacts and climate prediction.

One of the practical lessons we learned was that farmers in the region evaluate the credibility of information or advice based on its source. While they tend to be skeptical or at least cautious of "experts" from outside the community, they place a great deal of confidence in the agricultural extension service and in their county agents. It was obvious that, in order to achieve widespread understanding and use of climate forecasts, our research effort had to work closely with the state extension services.

Understanding Climate-Sensitive Decisions

Through a combination of interactions with agricultural decision makers and analytical model-based studies, we attempted to identify viable, climate-sensitive decisions that can benefit from forecast information. Decisions that farmers and extension personnel indicated might be adjusted in response to credible climate forecasts include: field preparation, marketing, livestock stocking rates and feed management, area planted to each crop, cultivar selection, and crop management.

In order to evaluate the potential for tailoring particular decisions to ENSO-related climate conditions, we conducted several retrospective decision analyses that combined historic climate information, crop simulation results, field-, farm- and market-scale economic decision models, and optimization techniques. Potential value of forecast information is estimated as expected returns to the best use of forecast information minus expected returns to the best use of historic climate information in the absence of forecasts.

For small-to-medium-sized field crop farms in southern Georgia, results suggest that the potential value of ENSO information for farm land allocation among crops is on the order of$4 to $6 ha^{-1} y^{-1} averaged across all types of years (Jones et al, 2000). The potential value for corn and wheat management is about $5 to $15 ha^{-1} y^{-1} (Jones et al., 2000; Hansen et al., 2001). Most of the potential benefit occurs in El Niño and La Niña years.

A more recent study of winter-grown tomato in South Florida indicates that a single farmer can increase average income by about $800 ha^{-1} y^{-1} by basing planting decisions on ENSO phases (Messina et al., in preparation). If all farmers were to optimize practices independently based on ENSO phases, negative price response would cancel out the production benefits because Florida represents such a large share of the U.S. winter fresh tomato market. However, if all of South Florida's tomato farmers were to coordinate their actions optimally, the average benefit from use of ENSO information would be about $300 ha^{-1} y^{-1} (Fig. 6).

Results of these and other similar studies are still quite tentative. They have not been conducted at enough locations to establish their generality. More important, they have not yet been evaluated by farmers under their own conditions. Nevertheless, our analytical studies and interactions with agricultural decision makers have convinced us that viable options do exist for using climate forecasts to improve farm decision making.

Delivering Climate Information

Around the time I left to join the IRI, our studies of ENSO impacts, farmer needs, and options for using forecast information caught the attention of Florida's extension administration, and gave us the credibility and confidence to move into a new, operational phase based on a research-extension partnership.

Given the lack of distinction in the minds of area farmers between weather and climate, an existing web-based weather information extension program provided an obvious entry point for climate information. The Florida Agricultural Weather Network, or FAWN, provides real-time weather data to growers through a system of automated weather stations distributed throughout Florida. The FAWN website (http://fawn.ifas.ufl.edu) has been redesigned to include background information on ENSO and its impacts, oriented toward farmers (O'Brien et al., 1999). Farmers have expressed interest in knowing how climatic impacts of ENSO vary both in space and time. Maps of mean seasonal temperature and precipitation anomalies associated with El Niño and La Niña show impacts at a relatively high spatial resolution. Monthly graphs show the seasonal patterns of means and anomalies of several agriculturally-relevant climatic variables for each ENSO phase (Fig. 7). Finally, users are provided with probabilistic presentations of monthly climate variables for any of 88 locations, expressed as time series plots or smoothed histograms, segregated by ENSO phase (Fig. 8). Current ENSO monitoring and forecast information, and ENSO-based freeze hazard forecasts have recently been added. Several climate-based decision tools are planned for FAWN, including aids for freeze protection, irrigation and pest management decisions.

Institutionalizing Support for Climate Applications

The next, ongoing step has been to establish a Statewide Major Program (SMP) on weather and climate in Florida. An SMP is the official mechanism for engaging extension specialists and county agents throughout the state. The program provides sustained state funds, supports ongoing training of extension personnel, justifies allocation of resources to climate-related extension activities and material development, and provides a mechanism for impact evaluation and for the feedback necessary to redirect research priorities. Most important, the SMP legitimizes our efforts in the eyes of agricultural stakeholders. Our long-term strategy will expand climate application extension programs into neighboring states, taking into account lessons learned in Florida. Cooperators in Georgia have already expressed interest and sought funding for a similar climate application program.

Conclusions

In spite of its distinctions, the Southeast US is, in many respects, analogous to other parts of the world where we believe seasonal forecasts can benefit agriculture. While seasonal prediction appears to offer considerable economic potential in the Southeast, realizing that potential remains a difficult, but not an insurmountable, challenge. A sensible approach to addressing the challenge in the Southeast or elsewhere must start with a foundation of understanding of (a) predictability of climate fluctuations and their agricultural impacts, (b) opportunities to use that information to improve decisions, and (c) agricultural decision makers and their socio-economic context, particularly the roles of institutions that influence them. Sustained benefit also requires the commitment of relevant, trusted institutions. At the IRI, we see ourselves as a strategic and facilitating partner in a growing network of institutions that are committed to the challenge of making the potential benefits of seasonal climate prediction a reality.

References

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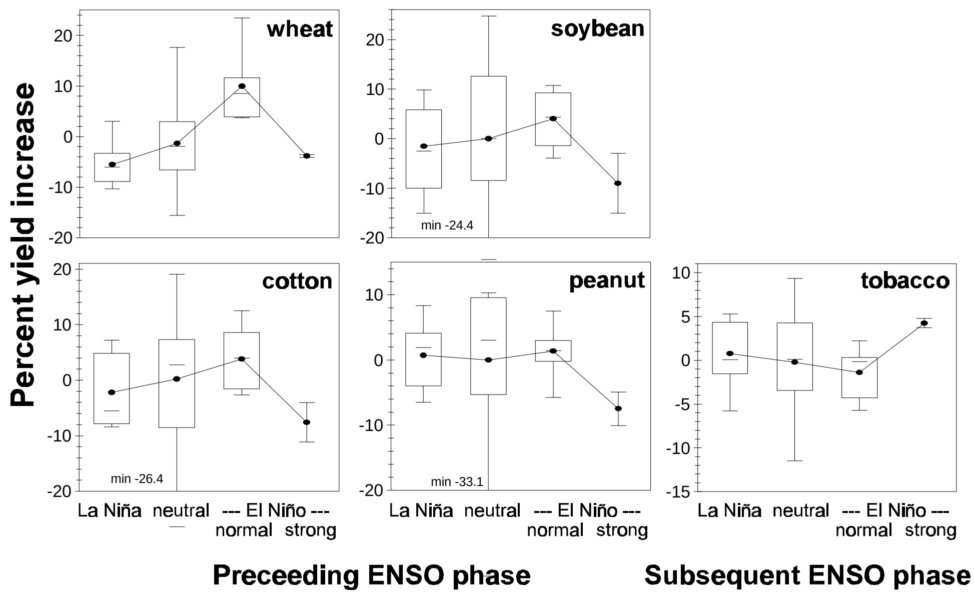

Figure 1. Box plots showing 0, 25, 50, 75 and 100th percentiles and average (circles) percent yield response of field crops to ENSO events in the Southeast US, 1965-1998. Source: Hansen et al., 2001.

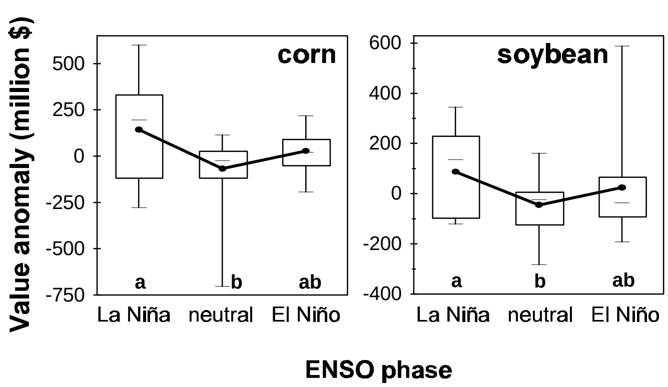

Figure 2. Box plots showing 0, 25, 50, 75 and 100th percentiles and average (circles) shifts of value of corn and soybean production in response to ENSO events in four states (FL, GA, AL, SC) in the Southeast US, 1960-1995. Source: Hansen et al., 1998a.

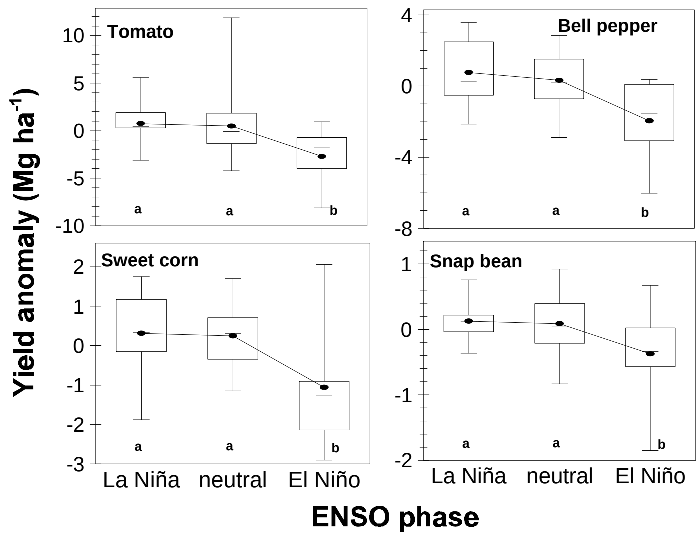

Figure 3. Box plots showing 0, 25, 50, 75 and 100th percentiles and average (circles) winter fresh vegetable yield response to ENSO events in Florida, 1951-1996 (sweet corn) or 1946-1996 (others). Source: Hansen et al., 1999.

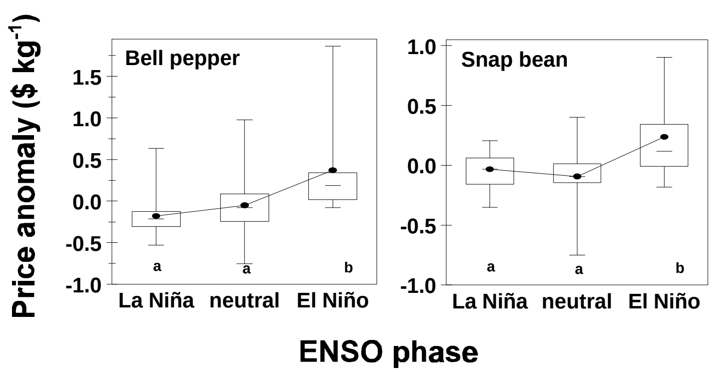

Figure 4. Box plots showing 0, 25, 50, 75 and 100th percentiles and average (circles) winter fresh vegetable price response to ENSO events in Florida, 1946-1996. Source: Hansen et al., 1999.

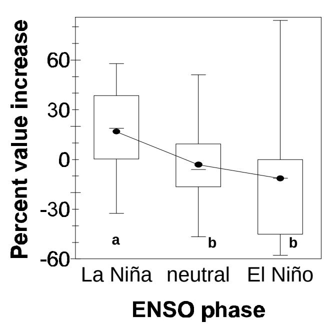

Figure 5. Box plots showing 0, 25, 50, 75 and 100th percentiles and average (circles) shifts of value of winter fresh tomato production in response to ENSO events in Florida, 1960-1995. Source: Hansen et al., 1999.

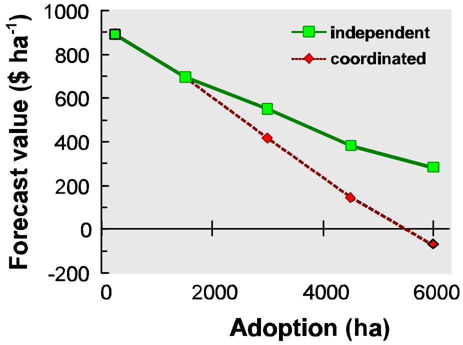

Figure 6. Potential value of ENSO information for Florida winter tomato planting decisions as a function of adoption without and with optimal coordination among farmers. Source: Messina et al., in preparation.

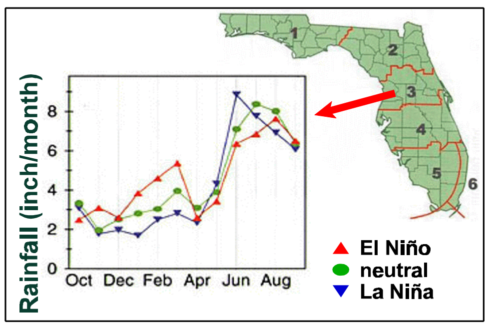

Figure 7. Monthly mean rainfall in Florida subdivision 3 in response to ENSO events. Source: O'Brien et al., 1999.

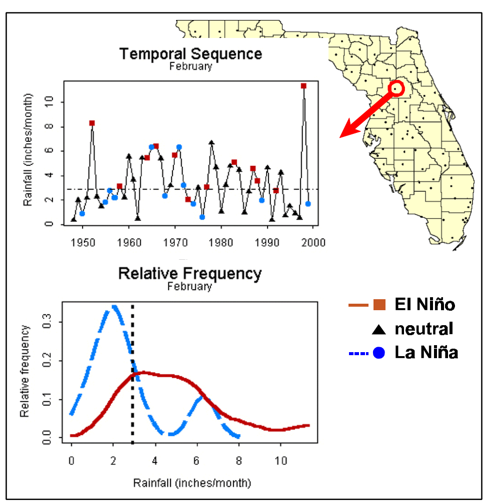

Figure 8. Probabilistic representations of ENSO influence on February precipitation at Ocala, Florida, available from FAWN (http://fawn.ifas.ufl.edu).